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Color Vision in Mentally Retarded Children

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COLOR VISION

IN

MENTALLY RETARDED CHILDREN

by

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ABSTRACT

Ninety-five mentally retarded (MR) males between 5 and 21 years of age were classified by level of I.Q. (20-35, 36-51, 52-67 and 68-85) and by type of MR (Down's Syndrome, DS; Chronic Brain Syndrome, CBS; Autosomal Genetic other than DS, AS; Genetic Sex-Linked, GSL; and Unknown Etiology, U). They were examined using the Hardy-Rand-Rittler Pseudoisochromatic plates, the Animal House subtest of the Wechsler Preschool and Primary Scale of Intelligence, and experimental tests of word-color associations and color naming. It was hypothesized that: a) there is a higher incidence of DCV in MR than in normal children and that there is an inverse relationship between the incidence of DCV and I.Q. level; b) DCV is more frequently found with MR due to genetic causes; c) children with DCV obtain lower scores than those with normal color vision (NCV) on the Animal House subtest, the word-color association test, and the color naming test. Results did not support any of these hypotheses. There was a trend for DCV to occur more frequently and more severely in genetically determined MR, but the N of the genetic subsamples was too small for drawing the conclusion with confidence. The work of other investigators was examined critically and suggestions were made for research methods which prevent the confounding of intelligence level and/or organic factors with color vision. The low incidence of DCV in this MR sample (5.3%), in contrast to the rates reported in recent literature (13.3% to 35.5%), was attributed to the confounding of important variables with DCV. The development of word-color association tests and color-naming tests to differentiate NCV from DCV was not supported.

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VITA

Ralph M. Mesenbrink was born in Oak Park, Illinois on May 13, 1934. He received his bachelor's degree summa cum laude in 1956 from Saint Mary's College, Winona, Minnesota where he also was elected to "Who's Who in American Colleges and Universities." In October 1956 he enlisted in the United States Navy and in March 1957 he was commissioned as Ensign. He served on active duty until November 1957.

He was awarded the Master of Arts Degree in Psychology from De Paul University in 1963. His clerkship and internship in clinical psychology were served in Downey Veterans Hospital, Loyola University Center for Child Guidance, and Hines Veterans Hospital.

Professional experience in psychology includes positions with: the Chicago Civil Service Commission as Examination Specialist and as Assistant Director of Training (1961 - 1963); Lewis College, Lockport, Illinois as Associate Professor and Director of Counseling (1963 - 1969); Du Page County Mental Health Center, Wheaton, Illinois as Chief Psychologist (1969 - Present). Part time experience includes consulting services to Will County Mental Health Center, Joliet, Illinois (1965 - 1969) and Trinity School for the Retarded, New Lennox, Illinois (1965 - Present).

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CHAPTER 1

STATEMENT OF THE PROBLEM

At one time it was assumed that incidence rates for defective color vision (DCV) were the same for normal and for mentally retarded populations (Tredgold, 1947; Kratter, 1957). More recently, however, this assumption has been questioned by the work of several investigators who have reported much higher than usual rates of DCV among retarded populations (O'Connor, 1957; Archer, 1964; Krause, 1967; Salvia & Shugerts, 1970). These results, if valid, have important implications for both the diagnostic methods of assessing the performance of, and the techniques and materials employed in the teaching of such children. If there proved to be a much higher incidence of DCV in retarded groups, and the color defect significantly affected test performance, then psychologists and teachers of special education would have to modify their methods of testing and teaching.

What is not entirely clear from the related research is the effect of intelligence, or of type of mental retardation on the diagnosis of color defect. This study attempted to control these factors which have been largely ignored in previously published work.

The principal aims of this research are as follows:

1) To determine the incidence of DCV in mentally retarded children by level of retardation. It was predicted that there is an inverse relationship between the incidence rate and the I.Q. level;
2) To study the relationship between type of retardation and the incidence of DCV. It was predicted that retardation due to

genetic causes is associated with color defect more frequently than retardation due to other factors;

3) To assess the implications of DCV for the psychological evaluation of mentally retarded children. It was hypothesized that at each I.Q. level, children with normal color vision (NCV) perform better than children with DCV. The Animal House Sub-Test of the Wechsler Pre-School and Primary Scale of Intelligence was used for this purpose (Wechsler, 1967);

4) To ascertain whether children with DCV differ from those with NCV in the ability to provide common color associations on the Color Completion Test (Appendix A). It was predicted that at each I.Q. level children with NCV perform better on this task than those with DCV;

5) To compare the performance of children with NCV and DCV on a simple Color Identification Test (Appendix B). Again, it was predicted that children with NCV perform better than those with DCV;

6) To evaluate the use of both the Color Completion and Color Identification Tests as simple screening devices for the detection of color defect;

7) To interpret the implications of this research for methods of teaching and types of teaching materials currently used with retarded children.

CHAPTER II

REVIEW OF RELATED LITERATURE

Historical Survey

In Theaetetus Plato suggested that colors might not appear the same to all people, but the idea did not reappear until the first scientific treatment of color deficiency in Turberville's (1684) paper to the Royal Society. In it he described a girl who saw "no colour beside Black and White." Kalmus (1965) suspected, however, that this was a case of hysterical color blindness. For the next hundred years after Turberville's paper there were only occasional reports of unusual color perception. Huddart (1777) and Scott (1778) each described families of color defectives (for expanded treatment of the historical background see Duke-Elder, 1962 and Kalmus, 1965).

Sixteen years later attention was focused again on the phenomenon by John Dalton's (1794) account of his own difficulties with color perception, as well as those of his brother and some twenty other subjects. This was the same John Dalton who introduced atomic theory to the field of chemistry ten years later. The color theory of Thomas Young, his contemporary, helped publicize Dalton's paper and this gave rise to the term "Daltonism" for color defect. The term was used for many years and remains most common in the French and Spanish literature (Duke-Elder, 1962).

By 1811 Wardrop recognized difficulties in red and green perception and in 1833 Herschel proposed the term "dichromatic vision." By 1837 Seebeck had introduced the technique of matching colored yarns to diagnose color defects. In 1876 Horner charted a long pedigree of color defect in a family. This study, along with those of Huddart (1777) and Scott (1778) contained the answer to the cause of most color defects, but the genetic explanation

had to wait until 1911 when Wilson proposed that Horner's law and Mendel's laws described the same situation, and that common color defects were carried by genes on the sex chromosome.

Diagnosis of color defect was aided by the publication of the first psuedo-isochromatic confusion charts by Stilling in 1877. Lord Rayleigh's experiments in 1881 with the yellow light emitted by sodium, the red light emitted by lithium, and green light from thalium provided the basis for the construction of the anomaloscope by Nagel in 1907. The anomaloscope remains the principal criterion for the classification of defective color vision.

Types of Defective Color Vision

Persons with NCV (about 92% of the Caucasian males and 99% of the females) are called trichromats (Kalmus 1965). This is because they require the use of all three primary colors, red, green, and blue to match all possible color sensations. Dichromats require only two primary stimuli to match all colors. There are three kinds of dichromats: 1) the protanopes who lack a red sensation, 2) the deuteranopes who lack separate red and green sensations but see yellow in place of both, and 3) the tritanopes who lack blue sensation. Monochromats, the only truly "color blind" persons, match colors with one another using only brightness. There are two types of monochromats, one with defective cone vision, the other with defective rod vision. Each is very rare. Proponents of the four-color theory postulate the existence of tetaranopes, but Kalmus (1965 p. 17) said none had ever been described and he doubted if they existed.

There are also persons who use all three colors in matching, but who

require intensities which differ from the normal trichromat. These are called anomalous trichromats and are sub-classified as: 1) protanomalous requiring more red stimulation; 2) deuteranomalous requiring more green; and 3) tritanomalous requiring more blue (see Table 1).

Incidence of Defective Color Vision

Table 1 presents the expected frequencies of DCV by type in a male Caucasian population. Overall occurrence of DCV in many different samples is summarized in Table 2.

The difficulty with interpreting the data in Table 2 is due to the unknown amount of bias in the sample selection in many of the studies and the lack of consistent diagnostic procedures and criteria. The figures generally accepted for the incidence of DCV in Caucasian males and females are 8% and 0.5% respectively.

Thus, it is clear that incidence rates may vary with geographical, racial, and sex variables. Post (1962, 1963) and Best (1963) have presented arguments for a relaxation in selection as peoples change from hunting to industrial cultures. Because keen color discrimination is no longer as necessary, those with color defects are more likely to survive and to have offspring which perpetuate the characteristic, according to this theory. However, two recent studies (Adams, 1969; Ray, 1969) have failed to support the hypotheses of Post and Best.

Almost the opposite point of view can be supported by work such as River's (1901) which approached the problem from an anthropological and linguistic viewpoint. He argued for the relationship between progress on an evolutionary scale from primitive to civilized and the frequency of color names occurring in language. At the lowest stage there was a term

TABLE 1

INCIDENCE OF COLOR DEFECTS IN CAUCASIAN MALES

(Based on Duke-Elder, 1962)

Color Vision	Percentage
I. Trichromatic	
A. Normal	91.8
B. Anomalous	
1. Protanomalous	1.0
2. Deuteranomalous	4.6
3. Tritanomalous	0.0001
II. Dichromatic	
A. Protanope	1.2
B. Deuteranope	1.4
C. Tritanope	0.0001
III. Monochromatic	
A. Rod	0.003
B. Cone	0.000001

TABLE 2

INCIDENCE OF DCV IN MALE POPULATIONS

(after Kalmus, 1965)

Subjects Sampled	Percentage Range	Subjects Sampled	Percentage Range
Europe:		Africa:	
English	6.8 - 9.5	Bechuanas	3.4
Scots	7.5 - 7.7	Bugandans	1.9
French	6.6 - 9.0	Bahutus	2.7
Belgians	7.5 - 8.6	Batutsi	2.5
Germans	6.6 - 7.8	Congolese	1.7
Swiss	8.0 - 9.0		
Norwegians	8.0 -10.1	North America:	
Czechoslovakians	10.5	U.S. Whites	7.2 - 8.4
Russians	6.7 - 9.6	U.S. Negroes	2.8 - 3.9
Jews (Russian)	7.6	Amerindians	1.1 - 5.2
Finns (Leningrad)	5.7	Eskimoes	2.5 - 6.8
Turks (Istanbul)	5.1	Canadian Whites	11.2
		Mexicans (urban)	4.7 - 7.7
Asia:		Mexicans (tribal)	0 - 2.3
Tatars	5.0 - 7.2		
Chinese	5.0 - 6.9	South America:	
Japanese	3.5 - 7.4	Brazilindians	0 - 7.0
Indians		"White" Brazilians	6.9 - 7.5
(caste Hindu)	0 -10.0	"Dark" Brazilians	8.8
Indians (tribal)	0 - 9.0	Brazilian Japanese	12.9
Isráelis	2.1 - 6.2		
Druses (Israel)	10.0	Australia:	
Filipinas	4.3	Whites	7.3
Fiji Islanders	0 - 0.8	Aborigines	2.0
Polynesians		Mixed	3.2
(Tonga)	7.5		

only for the color red; next appeared terms for red and yellow, and at the highest stage terms for green and blue appeared. Of course, what is not proven or demonstrated, is the one to one correspondence between a concept and a word for that concept. For example, a primitive tribesman might have been able to perceptually differentiate green and blue from other hues, even though he lacked the words in his language to make the distinctions verbally. A similar type of reasoning, the assumption of correspondence between perception and language, was used by Geiger (1880) when he concluded that the color vision of the ancients was defective because of the paucity of color language in their literature and songs.

Genetic and Organic Factors

An important variable which has not been controlled in previous research is the type of retardation. Color defect may be more common in certain types of retardation than in others (Wilson & Wolfensberger, 1963). Most DCV is due to sex-linked recessive inheritance. It would be expected, for example, that mental deficiency associated with a sex-linked genetic abnormality would also be accompanied by DCV more frequently than other types of retardation. In this way DCV might serve as a "marker" which would alert the examiner to the increased likelihood of other genetic sex-linked abnormalities and mental retardation.

Pleiotropism is the association of two mutant characters on the same gene. Linkage is said to occur when two characters are determined by two separate genes at two chromosomal loci which are nearby on the same chromosome. Kalmus (1965) has summarized studies demonstrating linkage between defective color perception and G6PD deficiency, the hemophilias, and Duchenne type of muscular dystrophy. In these studies DCV serves as a

"marker" to aid geneticists in mapping the loci of genes on the chromosomes. The recent study by Emery, Smith and Sanger (1969) on Becker type muscular dystrophy, color blindness and Xg blood groups employed the same methods. Table 3 presents the syndromes related to sex-linked (X-borne) defects.

In addition to disorders due to abnormal or defective genes and chromosomes, there are conditions which result from too many or too few chromosomes. These may be either autosomal or sex chromosomes. For example, Down's Syndrome (Mongolism) most often resultsfrom an extra 21st chromosome (Trisomy 21). The normal male carries one female and one male chromosome (XY) and the normal female carries two female chromosomes (XX). Klinefelter's syndrome usually results from two female and one male chromosome (XXY) and produces a male appearance. Despite the male appearance, the incidence of DCV in Klinefelter's syndrome seems to be that of females (0.5%) and is thus related to chromosome structure rather than physical appearance. Similarly, persons showing Turner's syndrome carry one female chromosome (XO), are like infantile females in appearance, but show color defect at the same high rate as males (8%). The presence of DCV in a person of female appearance should alert the examiner to rule out Turner's syndrome (Stewart, 1959; Kalmus, 1965).

In this investigation genetic defects will be categorized separately whenever evidence supports such conclusion at a high level of confidence. The genetic defects will be further sub-divided according to the following schema: (1) Autosomal Genetic, Down's Syndrome; (2) Autosomal Genetic, all other syndromes; and (3) Sex-linked Genetic. The first category was included because Down's Syndrome is found with sufficient frequency to

TABLE 3

TRAITS AND SYNDROMES IN WHICH X-BORNE GENES ARE INVOLVED

(after Kalmus, 1965)

Contribution of X Chromosome	Trait or Syndrome
Major	Partial color blindness, deutan series Partial color blindness, protan series Tritanomaly Glucose-6-phosphate dehydrogenase deficiency Xg blood group system Muscular dystrophy, Duchenne type, autosomal recessive mimic Muscular dystrophy, Becker type Haemophilia A Haemophilia B, Christmas disease Agammaglobulinaemia Hurler syndrome (gargoylism), recessive autosomal mimic more severe Late spondylo-epiphyseal dysplasia, similar to the autosomal Brailsford-Morquio syndrome Aldrich syndrome Hypophosphataemia Hypoparathyroidism of early onset, later autosomal form Nephrogenic diabetes insipidus Neurohypophyseal diabetes insipidus, autosomal mimics
Minor	Oculo-cerebro-renal syndrome of Lowe Hypochromic anaemia (Cooley-Rundles-Falls type) rarely X-borne Angiokeratoma diffusum corporis universale Dyskeratosis congenita Dystrophia bullosa hereditaria, typus maculatus Keratosis follicularis spinulosa cum ophiasi Ichthyosis vulgaris Anhidrotic ectodermal dysplasia Amelogenesis imperfecta, hypomaturation type Amelogenesis imperfecta, hypolastic type Absence of central incisors Congenital deafness Progressive deafness Mental deficiency Borjeson syndrome Spinal ataxia Cerebellar ataxia with extrapyramidal involvement Spastic paraplegia Progressive bulbar paralysis Charcot-Marie-Tooth peroneal muscular atrophy

TABLE 3 (continued)

TRAITS AND SYNDROMES IN WHICH X-BORNE GENES ARE INVOLVED

Contribution of X Chromosome	Trait or Syndrome
Minor	Diffuse cerebral sclerosis (Pelizacus-Merzbacher) Diffuse cerebral sclerosis (Scholz) Hydrocephalus Parkinsonism Ocular albinism External ophthalmoplegia and myopia Microphthalmia Microphthalmia, with digital anomalies Nystagmus Megalocornea Hypoplasia of iris with glaucoma Congenital total cataract Congenital cataract with microcornea Stationary night blindness with myopia Choroideremia Retinitis pigmentosa Macular dystrophy Retinoschisis Pseudoglioma Van den Bosch syndrome Menkes syndrome

justify independent treatment.

As was said earlier, most DCV results from sex-linked recessive inheritance. However, there are certain organic conditions which have been associated with color defects. Again, some of these are hereditary diseases and some are acquired. The more common of these disorders are listed in Table 4.

When considering disorders which involve the central nervous system, whether such disorders are acquired or hereditary, it is essential that the color researcher address himself to the distinctions among faulty color perception, low intellectual level, general language deficit, and impairment in the ability to abstract or categorize. Any of these could result in poor performance on color vision tests (see further, De Renzi & Spinnler, 1967).

Tests of Color Vision

There are many screening methods for detecting color defects. The most commonly used in the United States are the Ishihara, the Dvorine, and the H-R-R plates. The anomaloscope is the criterion against which such tests are measured for validity. The anomaloscope is a colorimetric device which permits the subjective color matching of one half of a small visual field with the other half by varying the wavelength or the intensity (brightness). Because of the complexity of examination by anomaloscope it is not suitable for young children (Kalmus, 1965).

The H-R-R Pseudoisochromatic Plates (Hardy, Rand & Rittler, 1957) were selected for this research for several reasons. First, it is widely used by ophthalmologists and optometrists. Secondly, it is appropriate for retarded and non-verbal children because it can be modified to require only

TABLE 4

ORGANIC SYNDROMES ASSOCIATED WITH DEFECTIVE COLOR VISION

(after Kalmus, 1965 and Duke-Elder, 1962)

Syndrome	Defect
Congenital jaundice	Extreme deuteranomaly
Albinism	Extreme deuteranomaly
Peripheral pigmentary dystrophy	Deuteranopia, blue-yellow and red-green defects
Central pigmentary dystrophy	Red-green, blue-yellow
Albipunctate dystrophy	Blue-yellow
Choroideremia	Blue-yellow
Sorsby's dystrophy	Red-green
Choroidal sclerosis	Blue-yellow, red-green
Fuchs's gyrate atrophy	Red-green
Vogt-Spielmeyer's disease	Red-green
Juvenile macular degeneration	Red-green
Senile macular degeneration	Blue-yellow
Gronblad-Strandberg syndrome	Blue-yellow
Cystic macular degeneration	Congenital: deuteranopia
Retinoschisis	Blue-yellow
Malignant Myopia	Blue-yellow, red-green
Retinal detachment	Blue-yellow, red-green
Siderosis	Blue-yellow
Chorioretinitis	Blue-yellow
Central serous retinopathy	Blue-yellow
Hypertensive retinopathy	Blue-yellow
Diabetic retinopathy	Blue-yellow
Retinal vascular occlusions	Blue-yellow
Choroidal malignant melanoma	Blue-yellow
Glaucoma	Blue-yellow
Drusen of the optic disc	Red-green, blue-yellow
Optic atrophy (dominant)	Blue-yellow
Optic atrophy (sex-linked)	Red-green
Papilloedema	Red-green, blue-yellow
Retrobulbar neuritis	Red-green
Chiasmal lesions	Red-green
Alcohol-nicotine intoxication	Red-green
Trauma, concussion, brain tumor	Red-green, blue-yellow

the tracing of three simple geometric figures with a small brush. And thirdly, the H-R-R test yields a qualitative classification of the type of defect (protan-deutan, red-green unclassified, tritan, tetaran, and blue-yellow unclassified) and a quantitative diagnosis to indicate the extent of the defect (mild, medium, strong).

In their review of color vision literature, Ripps and Weale (1969) concluded that "The Ishihara plates, while ideal for detection, are useless for the determination of the type of defect, and hence lose heavily to the H-R-R plates and the 15-hue test (p. 209)."

The authors of the H-R-R test studied its test-retest reliability by retesting a sample of 238 Ss on either the same or the second day. Of 131 Ss classified as normal on the first test, 130 were classified as such on the second test. Of 107 Ss classified as defective on the first test, 105 were diagnosed as defective in retesting (Hardy, Rand, & Rittler, 1954).

The suitability of the H-R-R test for young children was illustrated by the work of Gallagher and Gallagher (1964). In a study of 296 pre-school children who ranged in age from five to six and 300 first graders, they discovered only two children who were unable to understand the instructions, leading them to suggest " . . . in fact, there is reason to suspect that this test method could satisfactorily be used at an even earlier age (p. 209)."

Some support for the validity of the H-R-R plates came from Kalmus (1965) who said, "Their efficiency in detecting defective colour vision is about as good as that of the Ishihara charts (p. 39)." More substantial evidence came from the work of Krill, Bowman and Schneiderman (1966) who noted that the Ishihara plates yielded 41 (N = 530) false positives while

the Nagel anomaloscope and the H-R-R plates were in perfect agreement diagnosing these 41 as NCV.

Walls (1959) concluded that "For anyone who does not want anything more than a normal - abnormal screen . . . the H-R-R is acceptable. But for the conscientious work in the advising of employers and the vocational guidance of youth, there is no substitute for an anomaloscope (p. 192)." In his study Walls found that the H-R-R made no false positive diagnoses, but that it did identify three of 70 defectives as "normal."

Studies of Retarded Populations

At one time it was assumed that the incidence of DCV was the same for normal and for retarded populations (Tredgold, 1947; Kratter, 1957). However, O'Connor (1957) found 13.3% of a retarded sample of 119 to be color blind. This was a large increase from the 8% level but some experts (notably Dvorine, 1963) accept 12% as the rate of DCV in the general male population. There are a few qualifications which must be made in interpreting O'Connor's results. The 119 Ss were diagnosed "imbecile" on the basis of case records. There is no indication of individual or group testing of intelligence. Also, he reported that some of the children were considered to be schizophrenic. Further, the test he employed was the Ishihara, which is slightly more difficult in that it involves number recognition or tracing. And lastly, the lighting conditions varied from one testing to another.

Krattner (1957) found five of 63 Ss classified as "Imbecile" (7.9%) and five of 128 Ss (3.9%) classified as "Moron" to be color blind. He concluded "Generally speaking, color blindness does not appear to be more prevalent among the high-grade defective population than among people of

average intelligence . . . However, color blindness does occur twice as frequently in the low grade defectives, which, is attributed to the developmental anomalies more frequently observed in this group (p. 437)." Caution must be exercised in generalizing from his results because: (1) he did not specify I.Q. level or method of assigning Ss to either the Imbecile or Moron class, (2) he did not spell out the criteria on the Ishihara which he used to classify color blindness, (3) there was no indication of standardized lighting and testing conditions, and (4) he assumed a lower base-rate of DCV in the normal population than is indicated by most research.

Archer (1964) studied 1008 retarded children in special education classes in Colorado. He reported that 31% of the males and 26% of the females were color blind, using the Dvorine Plates as the criterion. The highest incidence was found in the youngest group, called the intermediate level. The ages for these children ranged from 9 to 12 years and the color blindness rates were 35.5% for males and 32.1% for females. Their I.Q.s ranged from 50 to 80. The test or tests were not specified but Archer indicated that all Ss were examined individually.

Archer's investigation must be inspected closely because his results are so much at variance with the work of others. Furthermore, there are some results within his own study which are difficult to understand. For example, he found a decreasing incidence of color blindness from Intermediate through Pre-Vocational and Vocational levels. This is equivalent to decreases in color defect with age, because all groups were educable mentally retarded, supposedly with I.Q.s between 50 and 80. There is no attempt to explain this phenomenon in his research other than to posit the

possibility of a color confusion which exists at earlier ages. To attack this problem more directly it would be necessary to compare the I.Q. mean scores for the DCV and the NCV groups. Without the control of the I.Q. variable it is possible that I.Q. and defective color perception were being confounded, and that poor performance on the color screening test was a function of low I.Q. Such control of the I.Q. variable is certainly necessary before lower performance on color-word association tests can be attributed to color vision.

In a recent survey of color blindness research with mentally retarded, Schein and Salvia (1969) cited an unpublished work by Krause (1967) which reported rates of 22.3% and 21.5% for retarded males and females respectively in a total sample of 609. Krause also concluded that color association and color blindness were independent variables, and thus would argue against the fourth hypothesis in this research (see page 2). No details concerning the experimental design, subject characteristics, or testing procedures in Krause's study were available.

Bursten (1969) wrote in a letter to the editor that her special education class had one child with such difficulty in appropriate color usage that she requested the entire class be examined for color defect. The six girls were found to be normal, but five of the nine boys were judged color defective. This finding led her to modify her teaching methods and the materials used. Again, no details are available concerning this report but it does serve to illustrate the interest in and the lack of knowledge concerning color vision in the mentally retarded.

If there proves to be a much higher incidence of color defect in retarded groups, and if the color defect is significantly related to I.Q.

level, diagnostic category, word-color associations and psychological test performances, then psychologists and teachers of special education will have to modify their methods of testing and teaching. Standardized psychological tests which might be influenced by DCV are the Halstead Categories Test, the Illinois Test of Psycholinguistic Abilities (Auditory Association and Verbal Expression sub-tests), the Stanford-Binet L-M (Vocabulary sub-test), the Rorschach, and the Wechsler Pre-School and Primary Intelligence Scale (Animal House sub-test). In this research the Animal House sub-test of the WPPSI was selected to determine the influence of DCV on test performance. Wechsler (1967) stated, "The colors of the Cylinders used for Animal House were carefully selected so that a color blind child will not be handicapped in performing this task (p. 11)." In response to an inquiry from this author, Wechsler said, "When the test was in the try-out stage, a number of examiners commented on possible difficulties that color-blind children might have with the red and green cylinders, originally included. These were accordingly eliminated and replaced by white and black ones. However, no prior study was made of the implied problem."[1]

Wechsler's statements appear logical for protans and deutans since there are no red and green cylinders in the test. However, Archer's (1964) work with a word-color association test suggested that children with DCV differ quite significantly from children with NCV on some surprising items. Among these were several words which demanded green, yellow, blue, and red responses. It may well be that a person's color vision defect can cause a generalized impairment in the handling of colored stimuli and need not affect only those hues to which he is insensitive. Furthermore, the tritan,

1. D. Wechsler, personal communication, August 6, 1969.

although much rarer than the protan or deutan, has difficulty with blue-yellow discriminations (Kalmus, 1965). The Animal House test does use blue and yellow cylinders.

An example of the relevance of color vision to teaching methods is provided by Frostig (1968) who said "Our usual method is to associate phonemes with graphemes from the beginning, writing each distinct sound in a word in a different color . . . Colors can also be used to teach syllabification, each syllable of a word being written in one color (p. 410)." Krause and Thomas (1969) examined a reading program for the use of colored clues and concluded that the red figure on a green background was the most common color clue. They also found: that the figure-background relationship usually involved at least one primary color; that green was the most frequent background; and the use of color clues became more frequent as readers advanced to the 3rd grade level. They suggested that children with difficulties in color vision be identified early to provide remedial aid. Procedures in color coding must be carefully evaluated even for normal male populations in which the incidence of DCV is approximately 8%. If the rate in retarded populations is significantly higher, even more caution must be exercised in applying such color techniques without evaluation.

CHAPTER III

METHOD

Subjects

Only males between the ages of 5 and 21, on whom there was an individual test of intelligence administered by a qualified psychologist were included in this study. Acceptable individual intelligence tests were limited to the Stanford-Binet and the Wechsler Intelligence Scale for Children.[2] Qualified psychologist, as used herein, refers to a clinical psychologist or school psychologist with a minimum of a master's degree in the appropriate field and one year of supervised experience.

An attempt was made to obtain complete testing and background data on 117 children covering the entire range of mental retardation levels. The loss of Ss in the sampling and testing process (detailed in Appendix C) resulted in an N of 95.

School systems which provided Ss for the study were: Joliet Elementary Schools, Joliet, Illinois; school systems participating in the Cooperative Association for Special Education, Wheaton, Illinois; and Trinity School for the Retarded, New Lennox, Illinois. A listing of individual schools and the number of Ss included from each is found in Appendix D.

For purposes of statistical analyses the I.Q. scores were grouped according to the categories in the Diagnostic and Statistical Manual (APA, 1968) based upon the recommendations of the American Association of Mental Deficiency. The Categories are: 20 - 35, 36 - 51, 52 - 67, and 68 - 85. When the N in each cell was too small to permit analysis by chi-square or similar

2. An analysis of the test results of 17 children in this sample who were examined between one and three years apart on the Binet and the WISC yielded r of .88.

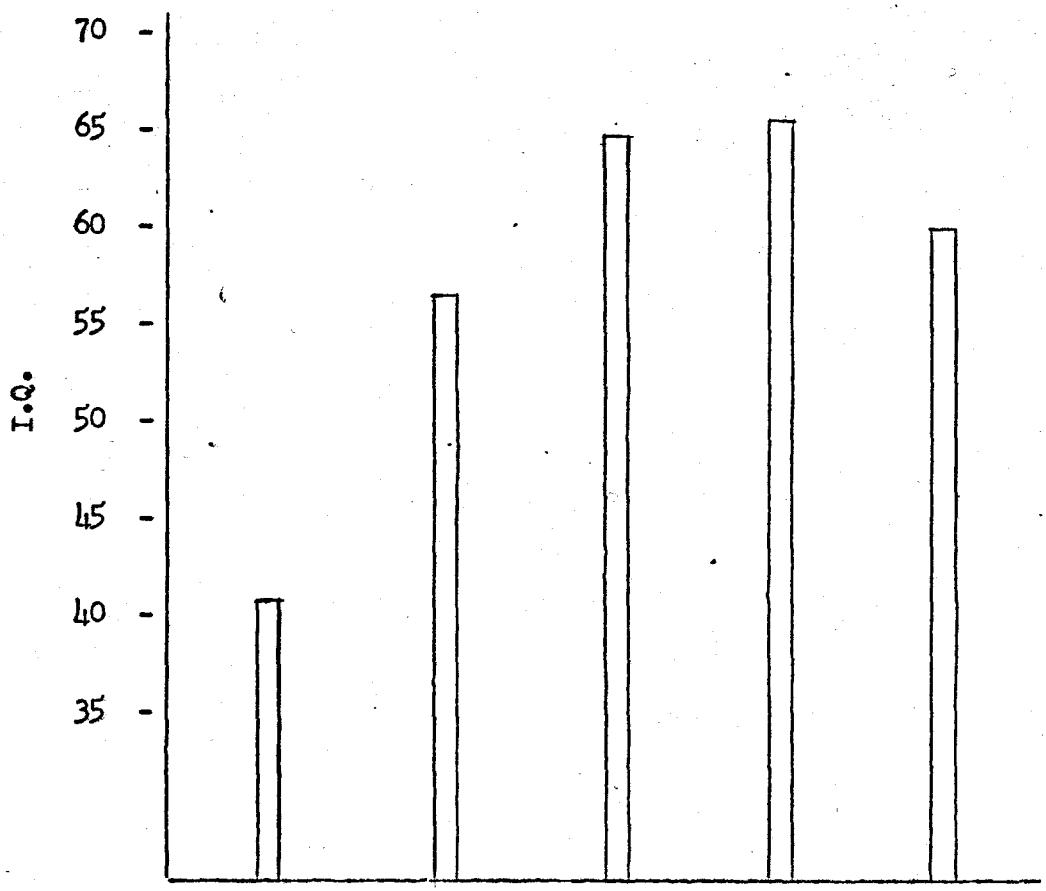
procedure, the first and second and the third and fourth categories were combined (Hays, 1963).

Diagnostic classifications as to the type of retardation were made by the investigator on the basis of the medical record, social history, and test results available. Because of the great number of hours required to read the entire school records of 117 children, no study for inter-rater or intra-rater reliability was attempted. Specific assignments of Ss to diagnostic category were made only when the investigator was confident in their accuracy. The diagnostic categories employed were: Down's Syndrome (DS), Chronic Brain Syndrome (CBS), Autosomal Genetic (AS) other than Down's Syndrome, and Genetic Sex-Linked (GSL). When there was insufficient data to make a diagnostic decision with confidence, the S was assigned to the "Unknown Etiology" category (U). As might be expected, this category included the largest number of cases. The results of these classifications, and the mean I.Q. and standard deviation for each are summarized in Figure 1.

Tests

Diagnosis of DCV was based upon the H-R-R pseudoisochromatic plates (Hardy, Rand, & Rittler, 1957). The child was classified as defective in color vision (DCV) if he failed test plates after screening plates (according to instructions in the manual). In addition, the category of weak color vision (WCV) was used to include those who failed screening plates but passed test plates; or those who had great difficulty with either the screening or the testing proper, but upon repetition could pass the plates which initially caused the difficulty.

Standardized lighting was provided by a 100 watt daylight blue incandescent bulb with a visible filament in a 180° reflector table lamp. The bulb



	DS	CBS	U	AG	GSL
Mean	40.8	56.8	64.6	65.4	60
SD	6.2	11.0	10.7	9.8	-
N	13	32	44	5	1

FIG. 1. I.Q. scores by type of retardation. DS = Down's Syndrome, CBS = Chronic Brain Syndrome, U = Unknown Etiology, AG = Autosomal Genetic (other than DS), GSL = Genetic sex-linked.

was positioned 12 inches from the plates, directly perpendicular to them, to avoid reflection on the plates and glare in the eyes of the S.

To determine the influence of DCV on a standardized psychological test the Animal House sub-test of the Wechsler Preschool and Primary Scale of Intelligence was used. It was administered according to the instructions in the manual. The other sub-tests were not given.

To assess differences between NCV and DCV in retarded children in terms of appropriate word - color associations the Color Completion Test (see Appendix A) was used. This test was written by this investigator for the current study and is similar to an instrument employed by Archer (1964) in his work. Archer investigated the test - retest reliability of his test with a one week interval between administrations and obtained r = .94.

The Color Identification Test (Appendix B) was designed specifically for this study also. This task, which uses eight plastic colored chips from the Peabody Language Development Kit, requires the S to point to each color, in a randomized order, in response to E's instruction. The order of presentation of each sub-set of eight colors was determined by drawing the chips from a box, without replacement.

Support for the development of instruments such as the Color Identification and the Color Completion Tests came from Kalmus (1965) who stated "Contrary to much "scientific opinion" colour naming can be most informative and useful in many situations, provided it is used critically . . ." Kalmus then described criteria for controlled color naming - "Colour defectives misname colours more frequently and their mistakes are more significant in situations where neither the context nor secondary clues, principally brightness, help. Such situations arise when a subject is

confronted with identical objects (paper, wool, blocks) which differ only in colour (pp. 30-31)."

When the entire battery was administered to an S, the materials were in the following order: Animal House Test, Color Completion Test, Color Identification Test, and H-R-R plates. This order of presentation precluded the E's knowledge of a diagnosis of DCV from affecting the administration and scoring of the other tests. In the course of the study, however, it became evident that the incidence of DCV was quite low, and that even Ss with severely defective color perception had no difficulty with the Animal House Sub-Test. Therefore, it was not administered routinely to all subjects, but only to those identified as DCV.

CHAPTER IV

RESULTS AND DISCUSSION

General Findings

The general results are presented according to the format outlined in Chapter I.

1. A major aim of the study was to determine the incidence of DCV in mentally retarded by level of I.Q. The first prediction, that there is an inverse relationship between the incidence rate and the I.Q. level, was not substantiated. As shown in Table 5, only five of 95 Ss (5.3%) were diagnosed as DCV. The total incidence was so small, and the frequency per cell so sparse that no conclusions can be drawn except that the results do not support the high frequency rates reported by others (O'Connor, 1957; Archer, 1964; Krause, 1967; Salvia, 1970).

A further analysis was made by classifying those with weak color vision (WCV) as defined in Chapter III. This resulted in 15 Ss diagnosed as WCV (15.8%) and 20 Ss diagnosed as either DCV or WCV (21.1%). Table 6 presents these data.

To permit a significance test of association between I.Q. level and color vision the two lower and the two higher I.Q. categories were combined as seen in Table 7 (which tests the data from Table 5) and Table 8 (which tests the data from Table 6). Neither Pearson x^2 value was significant.

2. The second major aim of the research was to study the relationship between the type of retardation and the incidence of DCV. Table 9 summarizes these data. Again, the prediction that genetic retardation is associated with color defect more frequently than are other types of

TABLE 5

INCIDENCE OF DCV BY LEVEL OF RETARDATION

Color Vision	I.Q. Range				
	20 - 35	36 - 51	52 - 67	68 - 85	Totals
Normal	5	27	28	30	90
Defective	1	1	1	2	5
Totals	6	28	29	32	95

TABLE 6

INCIDENCE OF DCV AND WCV BY LEVEL OF RETARDATION

Color Vision	I.Q. Range				
	20 - 35	36 - 51	52 - 67	68 - 85	Totals
Normal	5	20	24	26	75
Defective and Weak	1	8	5	6	20
Totals	6	28	29	32	95

TABLE 7

PEARSON x^2 TEST OF ASSOCIATION BETWEEN

I.Q. LEVELS AND COLOR VISION (NORMAL vs. DEFECTIVE)

Color Vision	I.Q. Range		
	20 - 51	52 - 85	Totals
Normal	32	58	90
Defective	2	3	5
Totals	34	61	95

Note.- $x^2 = .46$, not significant. With 1 df x^2 must be ≥ 3.84 for significance at the .05 level.

TABLE 8

PEARSON x^2 TEST OF ASSOCIATION BETWEEN

I.Q. LEVELS AND COLOR VISION (NORMAL vs. DEFECTIVE AND WEAK)

Color Vision	I.Q. Range		
	20 - 51	52 - 85	Totals
Normal	25	50	75
Defective and Weak	9	11	20
Totals	34	61	95

Note.- $x^2 = 1.51$, not significant. With 1 df x^2 must be $\geq$ 3.84 for significance at the .05 level.

TABLE 9

INCIDENCE OF DCV AND WCV BY TYPE OF RETARDATION

Color Vision	Type of Retardation					
	DS	CBS	U	AG	GSL	Totals
Normal	10	22	39	4	0	75
Weak	2	8	5	0	0	15
Defective	1	2	0	1	1	5
Totals	13	32	44	5	1	95

Note.- DS = Down's Syndrome; CBS = Chronic Brain Syndrome; U = Unknown Etiology; AG = Autosomal Genetic (other than DS); GSL = Genetic sex-linked.

retardation could not be statistically supported because only 5 Ss were diagnosed DCV. However, it can be noted that three DCV Ss were found in the genetic sub sample of 19 (DS, AG, GSL) whereas only two DCV Ss were found in the remaining 76 (CBS, U). Only one S was categorized as genetic sex-linked and, interestingly enough, that S was color deficient.

The relationship between DCV and genetic disorders which is suggested from these data does not hold for WCV and genetic disorders. Here it can be observed that the diagnosis of WCV was more frequently found with the chronic brain syndrome and the unknown etiology categories. One plausible explanation of such conflicting trends in the data would be to attribute the difficulty in taking the H-R-R test to the presence of central nervous system damage resulting in language deficit, visual perception difficulty, impairment in abstraction, or poor concentration. Such concomitants of brain damage could explain the ambiguous test behavior which results in alternately passing and failing the same test plates. This test behavior is probably not found in truly color deficient persons (see De Renzi & Spinnler, 1967).

3. It was hypothesized that children with NCV would perform better on the Animal House subtest than children with DCV. During the data collection it became obvious that even the most seriously color deficient S was not impaired on the Animal House subtest. One DCV S who was able to perform the H-R-R test, could not perform the Animal House task. The mean raw score of the four remaining DCV Ss was 52.3 (age equivalent of 6 years). There was no support for the concept that color deficiency might be related to a generalized impairment in the handling of colored stimuli (see page 17).

All Ss with DCV in this study were red-green deficiencies. Therefore, the effect of blue-yellow deficiency remains unknown. But the incidence rate for blue-yellow defect is so low (.0002) that the question will be quite difficult to settle. Further, it may have some theoretical, but virtually no clinical significance.

4. It was predicted that at each I.Q. level children with NCV would perform better than children with DCV on the Color Completion Test. The test of this hypothesis is presented in Table 10.

The main effect of color vision was significant at the .05 level; the main effect of I.Q. level and the interaction effect were significant at the .01 level. These relationships are clearer in Figure 2 which illustrates the greater difference between mean scores at the low I.Q. level compared to the near identical means at the high I.Q. level.

5. The comparison between children with NCV and DCV on the Color Identification Test is tested for significance in Table 11. The type of color vision had no effect on the Color Identification Test, but the scores were significantly related to I.Q. The F-ratio for the I.Q. main effect was significant beyond the .01 level. There was no interaction effect with the Color Identification Test. Figure 3 presents visually the presence of I.Q. main effect and the lack of either color vision or interaction effects between type of color vision and level of I.Q.

6. Neither the Color Completion nor the Color Identification Test demonstrated promise as a screening device for the detection of color defect. They were more sensitive to differences in intelligence than to differences in color perception. Even the Ss with the strongest color defects had little difficulty with the Color Completion and the Color Identification Tests if their I.Q.s were above 50. A recent study by Salvia

TABLE 10

ANALYSIS OF VARIANCE: COLOR COMPLETION TEST SCORES

BY TYPE OF COLOR VISION AND BY LEVEL OF I.Q.

Source	df	MS	F
Color Vision (R)	1	237.70	5.45 *
I.Q. (C)	1	742.18	17.02 **
RXC	1	568.33	13.03 **
Error	91	43.61	

* $p < .05$
** $p < .01$
N = 95

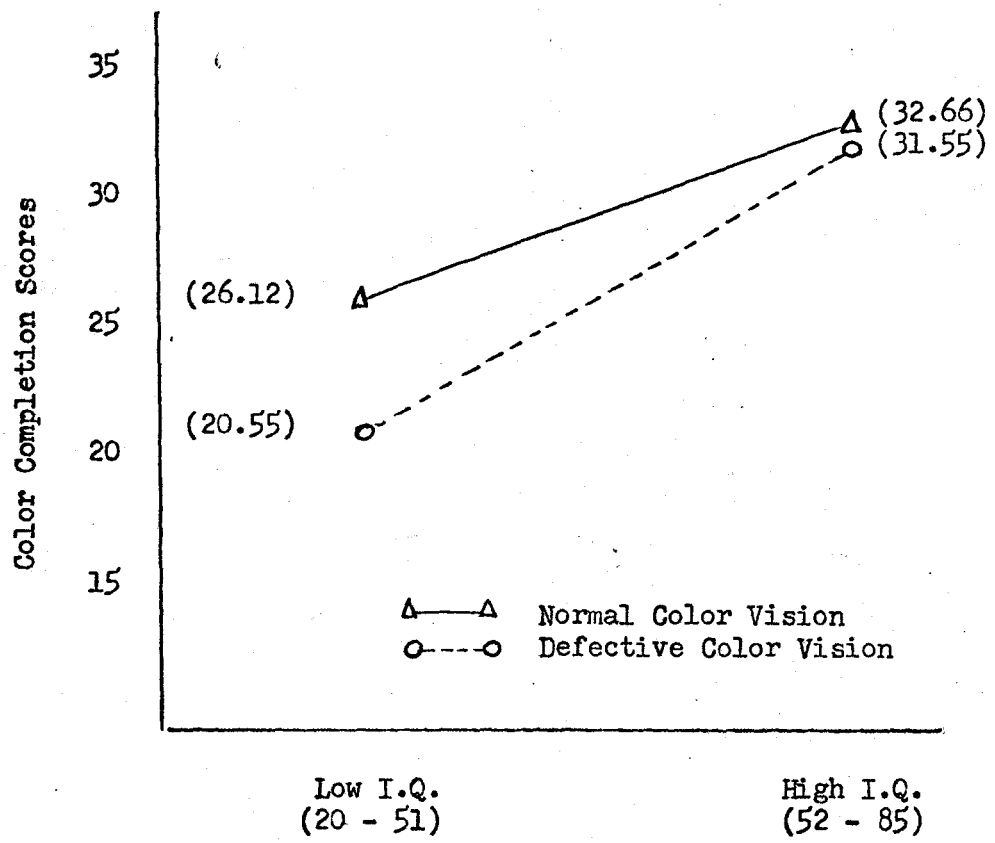


FIG. 2. The main and the interaction effects of I.Q. level and color vision on Color Completion test scores.

TABLE 11

ANALYSIS OF VARIANCE: COLOR IDENTIFICATION TEST SCORES

BY TYPE OF COLOR VISION AND BY LEVEL OF I.Q.

Source	df	MS	F
Color Vision (R)	1	.34	.02
I.Q. (C)	1	143.05	8.04 **
RXC	1	3.29	.18
Error	78	17.80	

** $p < .01$
N = 82

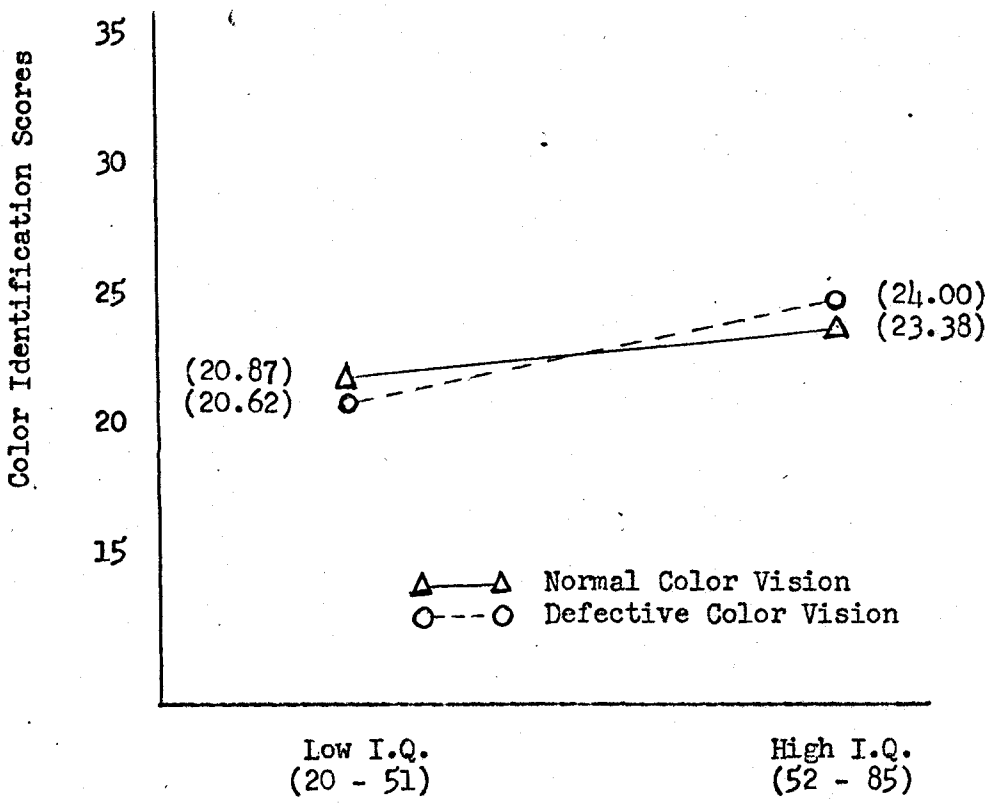


FIG. 3. The main effect of I.Q. level on Color Identification Test Mean Scores and the absence of Color Vision or interaction effects.

and Shugerts (1970), published since this research was completed, yielded essentially the same results. They used a color matching task, the color naming section within the Dvorine test, and Archer's (1964) Word-Color Association Test. No significant differences were found between 10 children with NCV and 10 with DCV on any of these tasks. Their findings, combined with those of Krause (1967) and those of this investigator, uniformly support the conclusion that abilities in word-color association and in color naming are independent of color perception as measured by the screening tests.

7. This research adds no new implications for teaching techniques and materials for retarded children. If it had supported the results of other researchers who reported DCV rates in the .30's, new cautions would have to be observed.

It does serve to recall and reinforce practices which should become standard. For example, syllabification with color codes (and similar techniques) should always be based upon hues which are most easily distinguished by children with DCV (black, white, blue, and yellow). Teachers should be cautioned that the inability to name hues correctly and/or to provide common word-color associations is not indicative of faulty color perception. Conversely, the ability to perform such tasks is not sufficient evidence of normal color perception. Color screening with a test such as the H-R-R is efficient enough to justify its use as a routine screening procedure. The examiner should be experienced in testing retarded children, or trained by someone who is, so that faulty performance which is due to low intelligence, auditory or visual perceptual difficulties, attention and concentration problems, etc., may be

differentiated from faulty performance due to defective color perception.

Some Case Studies

S59 is one of five children, three of whom are retarded. He has one brother and one sister who are normal, his two other brothers are retarded. S's father comes from a family with no known retardation, but his mother has two brothers, both of whom are retarded. His retardation has been attributed to a sex-linked genetic trait, which means that the female family members carry the gene, but are not afflicted with the disorder it produces. All sons of such carriers have a 50/50 chance to be affected. S59 obtained an I.Q. of 60, Animal House raw score of 52, Color Completion score of 31, and a perfect Color Identification score of 24. On the H-R-R plates he was diagnosed as demonstrating a medium protan defect.

S75 had multiple congenital anomalies, among which were polydactyly (six fingers on each hand), hernia and flat feet. In testing he obtained an I.Q. of 70, Animal House raw score of 48, Color Completion of only 23, perfect score of 24 on Color Identification. The H-R-R test portrayed him as having a strong protan defect.

S95 was classified as CBS and there was supporting evidence from the history, a series of EEG's, and a neurological examination. He obtained the following scores: I.Q. 70; Animal House 60; Color Completion 34; and Color Identification 24. His protan color defect, as evidenced by 17 errors on the H-R-R test, was the most severe in the study. Yet his performance on all the other color related tasks was superior.

These case studies are presented to demonstrate that there is no substitute for a test which measures color perception, as opposed to tests which measure word-color associations and color naming.

Discussion

The results of this study should be interpreted with these cautions in mind.

(1) The sampling drew chiefly from urban and suburban populations; rural populations might be characterized by a higher frequency of certain diagnoses (for example, familial retardation).

(2) The assignment of Ss to diagnostic categories of retardation was based upon the judgment of the investigator; diagnosis of genetic disorder was based upon medical reports and physical symptoms and not supported by chromosome studies.

(3) The diagnosis of DCV was based upon the H-R-R plates and not upon examination by anomaloscope, commonly accepted as the most valid measure of DCV.

Certain aspects of this study which are strongly recommended for related studies in the future are enumerated below.

(1) The use of standardized lighting procedures for the color vision testing.

(2) Assignment of Ss to levels of retardation and the use of individual psychological evaluations, rather than class placement, to make such assignment.

(3) Assignment of Ss to types of retardation, whenever possible, on the basis of careful evaluation of all medical, social, and psychological data available.

(4) Use of color screening tests which are appropriate to the mental age of the Ss. The present work supported the implication from Gallagher and Gallagher (1964) that the H-R-R test would be suitable with mental

ages below five years. In the experience of the present investigator, retarded children with mental ages as low as three and one-half could perform the test.

(5) Selection of color screening tests which are supported by validity studies using the anomaloscope as the criterion. Further reliability and validity studies are needed for all the major color-vision tests.

In addition to the above recommendations, the following clinical suggestions are offered.

(1) Routine screening for DCV such as urged by Wilson and Wolfensberger (1963) is reiterated here. Such screening is efficient in terms of time and cost and the results are important both clinically and theoretically. The diagnosis of DCV is important clinically because of its implications for vocational counseling and for alerting specialists to the increased likelihood of further congenital anomalies. It is important theoretically because of its use as a marker variable in mapping the chromosomes and its potential to aid in other genetic diagnoses.

(2) Because ophthalmologists, optometrists, and psychologists will not be able to meet the screening needs, other specialists, such as public health nurses and vision technicians, should be trained to do so. The color vision screening could be added to vision, hearing, and speech screening which is now performed in most elementary schools. School and clinical psychologists could train personnel in testing techniques with young children and with those of low mental age. Differences in training and experience in testing in general and in dealing with such populations in particular may account for the large discrepancies in rates of DCV

which researchers report.

(3) Teachers of special education should be informed that faulty color naming or inadequate word-color associations are not related to DCV, nor are abilities in those areas indicative of NCV.

The most important single implication of this study, which cannot be stressed too heavily, is that researchers and clinicians working with retarded populations must take care that intelligence and the dependent variable are not confounded. The conclusion of this investigator is that previous work (O'Connor, 1957; Archer, 1964; Krause, 1967; Bursten, 1969) has confounded intelligence and color vision.

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APPENDIX A

Color Completion Test
Ralph M. Mesenbrink

R	P			R	P
___	___	1. A baseball is _____.	20. An elephant is _____.	___	___
___	___	2. Chocolate is _____.	21. Coal is _____.	___	___
___	___	3. A dollar bill is _____.	22. Catsup is _____.	___	___
___	___	4. An apple is _____.	23. A leaf is _____.	___	___
___	___	5. Grass is _____.	24. Corn is _____.	___	___
___	___	6. Water is _____.	25. Milk is _____.	___	___
___	___	7. A lemon is _____.	26. Butter is _____.	___	___
___	___	8. The moon is _____.	27. Blood is _____.	___	___
___	___	9. The stop light is _____.	28. The go light is _____.	___	___
___	___	10. A nut is _____.	29. Cotton is _____.	___	___
___	___	11. A banana is _____.	30. Fire is _____.	___	___
___	___	12. Teeth are _____.	31. A tomato is _____.	___	___
___	___	13. Bread is _____.	32. Toast is _____.	___	___
___	___	14. The sky is _____.	33. A fire truck is _____.	___	___
___	___	15. A pumpkin is _____.	34. Snow is _____.	___	___
___	___	16. A carrot is _____.	35. Wood is _____.	___	___
___	___	17. A crow is _____.	36. A grapefruit is _____.	___	___
___	___	18. An orange is _____.	37. Mustard is _____.	___	___
___	___	19. Root beer is _____.	38. Night is _____.	___	___

Note.- R = verbal response, P = pointing response, to color chip
Maximum score = 37 as grey response, number 20, was deleted in final analysis.

APPENDIX B

Color Identification Test
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Series I		Series II		Series III	
White	_____	Yellow	_____	Grey	_____
Blue	_____	Blue	_____	Brown	_____
Red	_____	Orange	_____	Yellow	_____
Yellow	_____	Green	_____	Blue	_____
Green	_____	Red	_____	Orange	_____
Grey	_____	Brown	_____	Black	_____
Black	_____	Black	_____	Green	_____
Brown	_____	Grey	_____	Red	_____
Orange	_____	White	_____	White	_____

Series I _____ Series II _____ Series III _____

Total Score _____

Note.- Grey responses were not scored in the final analysis
Maximum score = 24.

APPENDIX C

REDUCTIONS IN SAMPLE SIZE BY CAUSE OF LOSS

Status in Sample	N
Original selection	117
Parents declined permission	2
Excluded by examiner (I.Q. too high; primary emotional disturbance)	4
Absent on days of testing	5
Untestable (all trainable level, unable to perform test tasks)	11
Subjects remaining in study	95

APPENDIX D

INDIVIDUAL Ss BY SCHOOL

School	Status in Sample					
	Originally Sampled	Parents Declined	Excluded by Examiner	Absent on Test Day	Untestable	Included in Study
Joliet Public Schools:						
Culbertson (EMH)	3	-	-	-	-	3
Reedswood (EMH)	3	-	-	1	-	2
Gompers (EMH)	5	-	-	1	-	4
Rehn (EMH & TMH)	14	-	-	1	2	11
Cooperative Association for Special Education Schools:						
Longfellow, Wheaton (EMH)	8	-	-	-	-	8
Cloverdale, Bartlett (TMH)	23	1	1	2	4	15
Edison Jr. High, Wheaton (EMH)	8	-	-	-	-	8
Hammerschmidt, Lombard (EMH)	14	-	1	-	-	13
Glen Crest Jr. High, Glen Ellyn (EMH)	6	-	-	-	-	6
Sandburg Jr. High, Wheaton (EMH)	8	-	-	-	-	8
Lincoln, Glen Ellyn (EMH)	6	1	-	-	1	4
Trinity School for the Retarded, New Lennox (TMH)	19	-	2	-	4	13
Totals	117	2	4	5	11	95

APPENDIX E

TYPE AND EXTENT OF DEFECTIVE COLOR VISION BY DIAGNOSTIC CATEGORY (N = 5)

Type of Defect	Extent of Defect		
	Mild	Medium	Strong
Protan	-	GSL	AG, CBS
Deutan	-	-	DS
Red-Green unclassified	CBS	-	-
Tritan	-	-	-

Note.- DS = Down's Syndrome; CBS = Chronic Brain Syndrome; AG = Autosomal Genetic; GSL = Genetic sex-linked.

APPROVAL SHEET

The dissertation submitted by Ralph M. Mesenbrink has been read and approved by members of the Department of Psychology.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

January 18, 1971
Date

Frank J. Kobler
Signature of Adviser